The power needed to push a bicycle and rider is mainly required for the road load which consists of the Gravity, Aerodynamic drag and Rolling resistance which is shown in (1) to (5):

Gravity force is described by:

(1)

Where

G is the steepness of the hill in terms of percentage grade

W is the Sum of the cyclist and bicycle weight.

Rolling resistance can be calculated by:

(2)

Where Crr is the coefficient of rolling resistance

Aerodynamic drag acting on the bicycle and cyclist is calculated as:

(3)

Where

V is cyclist velocity (m/s)

A is cyclist’s frontal Area(m2)

Rho (kg/m3) is air density and Cd is drag coefficient.

The total force that is needed to push the cyclist is the sum of these three forces:

(4)

The total power needed is:

(5)

3-Choosing Appropriate electric motor for E-Bicycle

to provide the needed power in electric vehicles, high torque and power density, high efficiency and high reliability electric machines can be used.

switched reluctance motors, by having a robust rotor and stator structure and lack of magnets in their structure, can be a cost-efficient choice. (ali emadi/srm for ebicycle) but suffering from high torque ripple up to 100 percent of the nominal torque, low power and torque density and low efficiency makes it not the best choice for this application.

currently, electric bicycle market is dominated by brushless dc motors (BLDCM) due to their high power and torque density, driving simplicity and low-cost manufacturing process

advantages like high torque and power density, less torque ripple compared to switched reluctance motor and higher efficiency of BLDC machine, have made this machine a suitable choice for use in electric bicycle (axial flux bldc for eb) on the other hand high manufacturing cost and low reliability….?

permanent magnet synchronous machines (PMSM) are highly efficient and compact machines with lower torque ripple and sinusoidal back EMF

PMSMs divide into two categories, interior permanent magnet (IPM) and surface-mount permanent magnet (SPM)

which has less torque ripple compared to IPM

in order to increase the power density, concentrated winding can be applied, although cogging torque will increase by using a concentrated winding

lower efficiency in low-speed applications like electric bicycle, is caused to mostly use a mechanical gearbox beside the BLDC or PMSM machines

flux switching machines not only have PMSM advantages like high torque and power density but also have lower cogging torque and torque ripple and can produce higher torque in lower speeds thanks to magnetic gearbox effect which is one of the innate features of this machine that makes this machine suitable for electric bicycle application

Design of an Outer-rotor FSM for E-bicycle

1. FSM topologies

There are two main topologies for flux switching machines One with permanent magnet (PM) inside of stator structure (SPMFSM) and another with PM mounted in Rotor Segments (RPMFSM), by mounting PMs in stator structure, controlling PM Temperature would be easier, although putting PMs in stator will cause lower torque density and higher torque ripple, for achieving the same torque density in SPMFSM in comparison to a RPMFSM, about two times PM volume will be needed. Since high torque density is needed in an EV application, RPMFSM topology would be a wise choice.

1. Design process

1-basic assumptions (dimension range-speed-power)

2-airgap selection

3-

To determine the machine’s dimension, the equation between apparent power, electrical and magnetic loading can be used which is described by:

Which Si is apparent power, D is airgap Diameter l’ is stack length and nsyn is applied armature current frequency

C coefficient is also described by:

Which Kw is winding factor, Â is Peak electrical loading and B̂δ is maximum airgap flux density

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Design stuff….

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